



Gasoline Sulfur Effects On LEV Emissions

EPA Workshop on Gasoline Sulfur
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Public Policy Center



Sulfur/LEV Program Comparison

CRC

Test Fleet

12 Vehicles, 6 models
5 Manufacturers
4-Cyl, 6-Cyl
All PC
All LEV Production

Vehicle Status

As Received (10K Miles)
100K Aged

Fuels

Non-Oxygenated
Industry Avg.
 @ 40,100,150,
 330,600 ppmS
California Phase 2 Cert.
 @ 40,150 ppmS

AAMA/AIAM

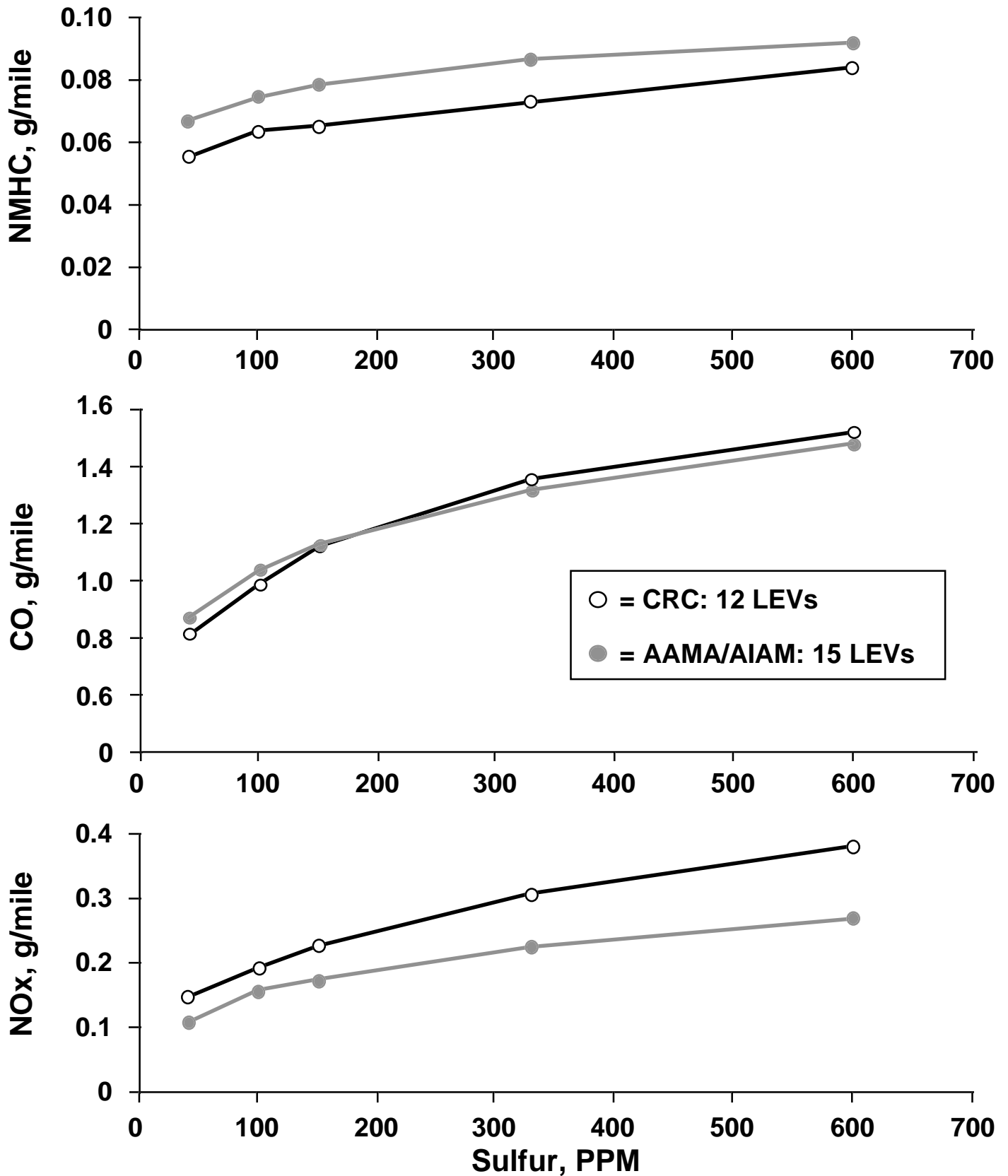
21 Vehicles, 21 Models
10 Manufacturers
4-, 6-, and 8 Cyl
14 PC, LDT1; 7LDT2,LDT3
15 LEV Production/
 Production Intent
6 ULEV Production/
 Production Intent

50K or 100K Aged

California Phase 2 Cert
 @ 40,100,150,
 330,600 ppmS



Comparison of Sulfur/LEV Programs Means From Ln-Ln Transformation: Aged Catalysts (Maximum Likelihood Estimates)





Comparison of LEV/Sulfur Test Program Results

LEV Fleet Sulfur Effects

FTP Composite Results with Aged Components

CRC

AAMA/AIAM

600 ➡ 40 ppmS

NMHC

- 32%

- 29%

CO

- 46%

- 47%

NOx

- 61%

- 58%

40 ➡ 600 ppmS

NMHC

+ 46%

+ 41%

CO

+ 86%

+ 88%

NOx

+156%

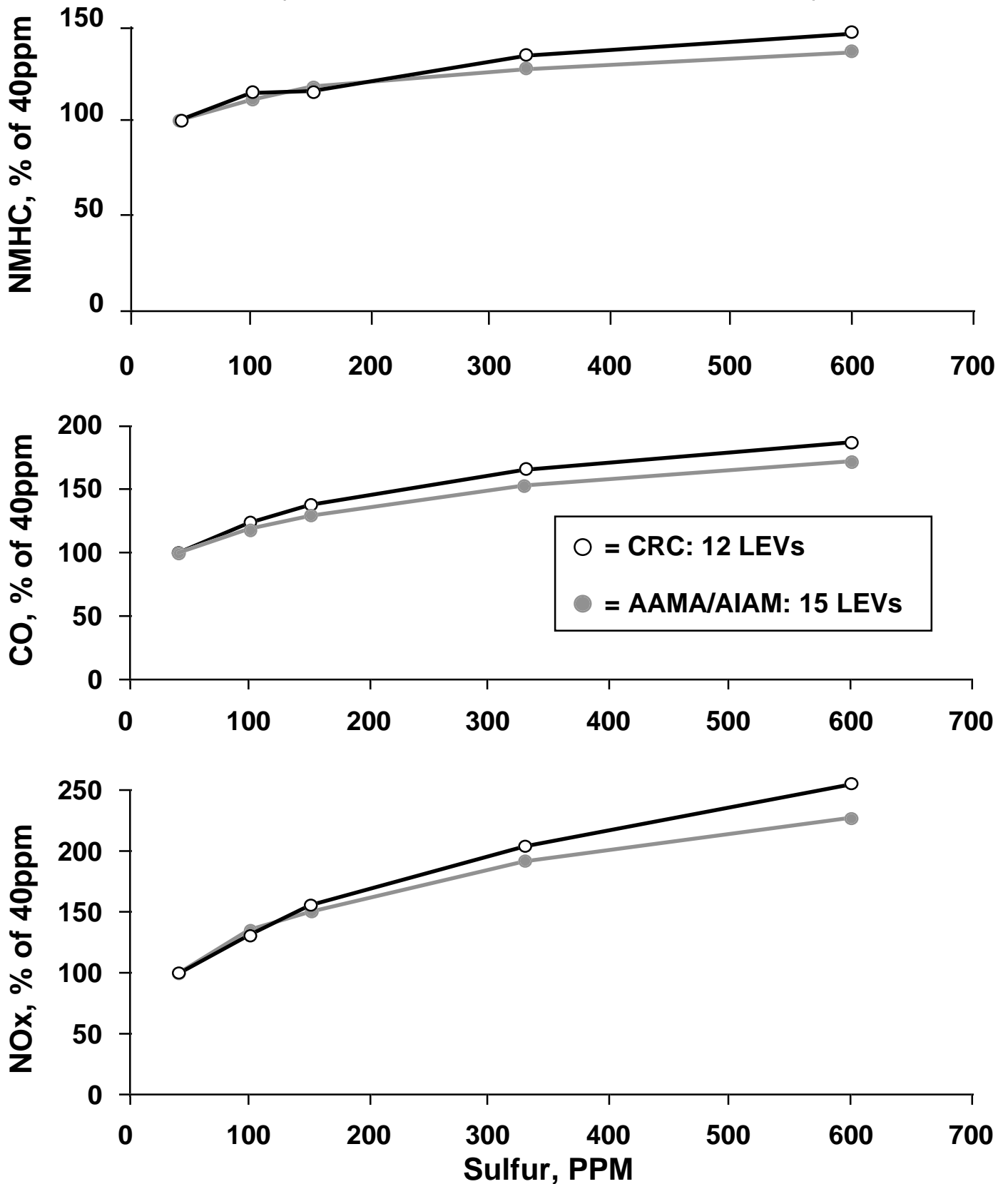
+133%



Comparison of Sulfur/LEV Programs

Percent Change from Base Fuel: Aged Catalysts

(Maximum Likelihood Estimates)



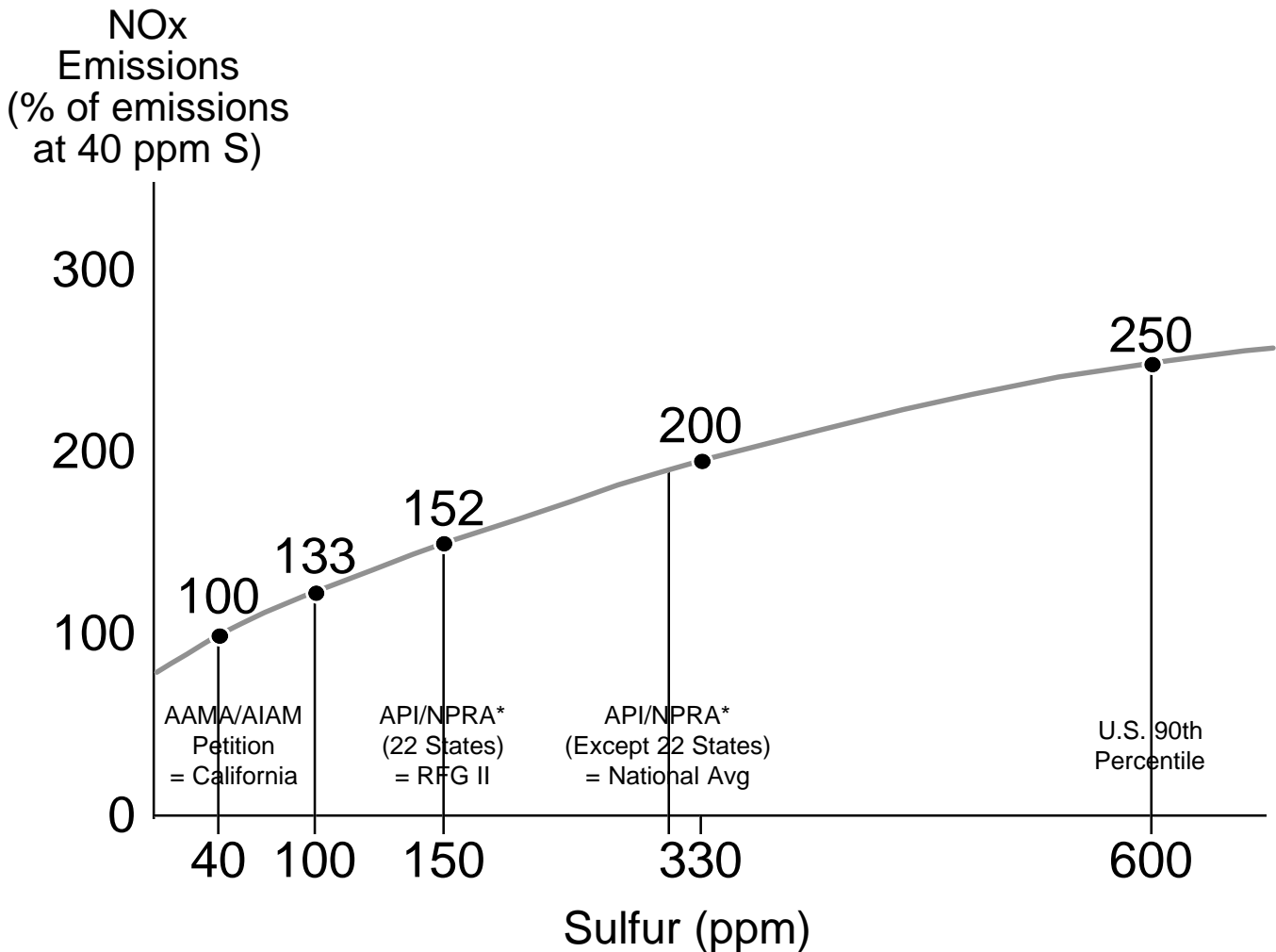


Effect of Gasoline Sulfur on LEV/ULEV Vehicles Conclusions from Test Fleet Averages

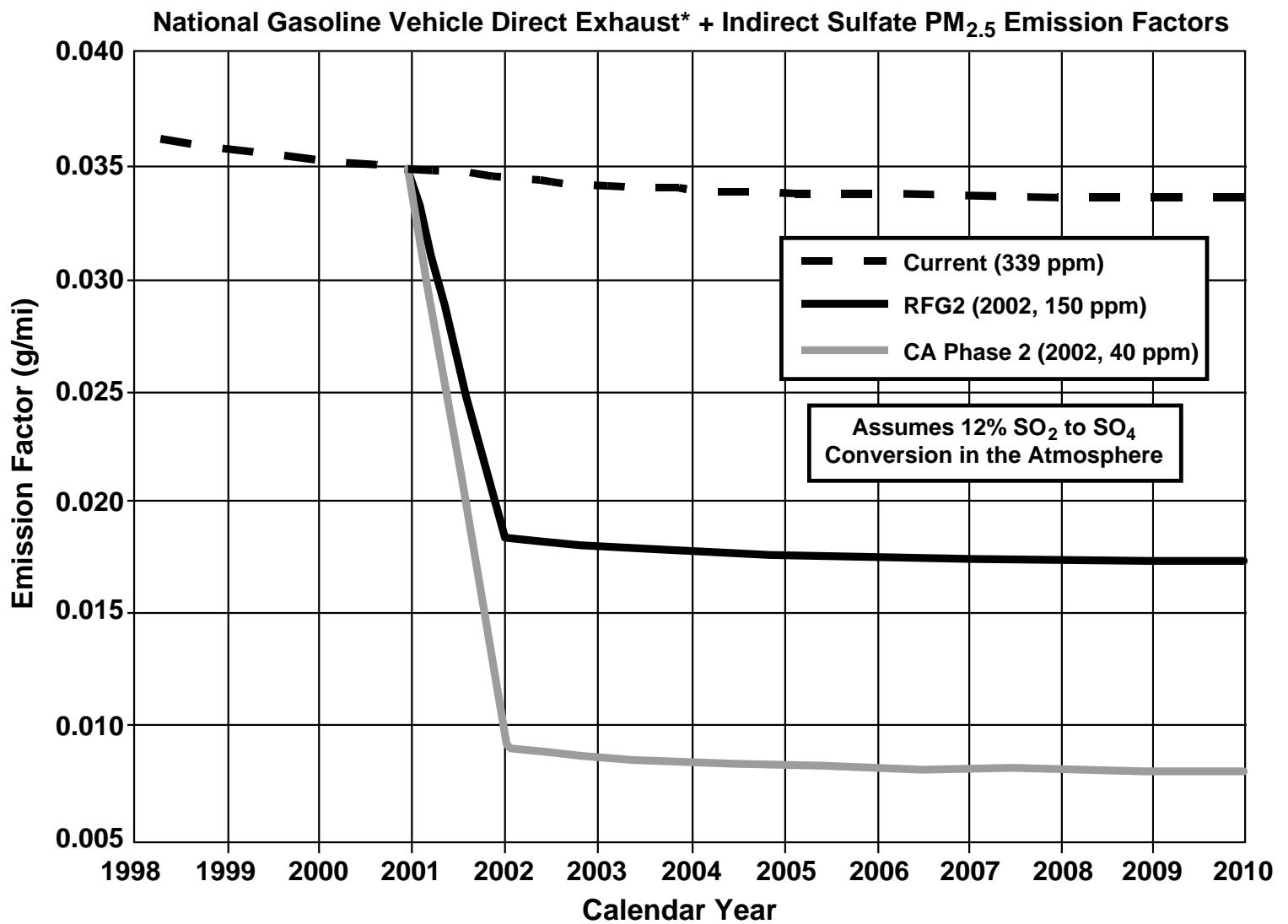
- **Impact of Gasoline Sulfur on Emissions**
 - Reducing Sulfur Produced Statistically Significant Reductions in LEV and ULEV Emissions of NMHC, CO and NO_x
 - The Benefits of LEV and ULEV Technology Diminish as Fuel Sulfur Increases Above 40 ppm
 - Sulfur Had a Substantially Larger Percentage Impact on LEV and ULEV Vehicle Emissions than on the Tier 0/Tier 1 Vehicles Tested in Auto/Oil AQIRP
- **Emissions Response to Sulfur**
 - For Tests with Aged Components, LEV and ULEV Fleet Emissions Response to Sulfur Was Non-Linear
 - The Largest Detriment Occurred at Low Sulfur, That Is, There is Significantly Greater Emissions Benefit In Reducing Sulfur From 150 to 40 ppm Than From 330 to 150 ppm
- **Compliance With 100,000 Mile Emission Standards**
 - For the AAMA/AIAM Test Vehicles, Tested On California Phase 2 Fuel
 - All Vehicles Complied with the NMHC, CO and NO_x Limits on 40 ppmS Fuel
 - At or Below the National Sulfur Average Level of 330 ppmS:
 - 7 of 21 Failed the NMHC Limit
 - 2 of 21 Failed the CO Limit
 - 8 of 21 Failed the NO_x Limit



Combined AAMA/AIAM & CRC Sulfur/LEV Studies



*Proposal for 2004, Summer Only



* Omits Brake and Tire Wear

Air Improvement Resource, Inc.



Reversibility of Sulfur Effects

- **Loss of Catalyst Efficiency Will Continue Even When Low Sulfur Gasoline Is Used Because Much of the Fleet Will Not Experience the Conditions Necessary to Reverse the Sulfur Effect**
 - LEV and Lower Standards, Need for High Catalyst Efficiencies Curtail Rich A/F Operation
 - Rich Operation Will Be Nearly Eliminated by SFTP Requirements in 2000 MY
- **National (Not Regional) Sulfur Control is Needed**
 - Sulfur Effect Is Likely Not Reversible Under Actual Operating Conditions
 - High Probability of Use of High Sulfur Gasoline (≥ 50 ppm) Means That Catalyst Will Be Poisoned Much of the Time



Variation in Vehicle Sensitivity to Sulfur

- **Fleet Emissions Affect Air Quality and SIP Credits**
- **Variation in Vehicle Response to Sulfur Results from Design Differences to Accommodate Customer Requirements**
- **The Least Sensitive Vehicle Tested by CRC Showed a 49% Increase in NO_x Emissions at the National Average Sulfur Level**
- **Fleet Emissions Will Always be Improved by Reducing Sulfur**



Effect of Gasoline Sulfur on LEV/ULEV Vehicles Interpretation of Results of CRC and AAMA/AIAM Test Programs

- **Sulfur in Gasoline Increases Vehicle Emissions Of**
 - NMHC, CO and NO_x
 - Toxics
 - Methane
 - Increases Observed at Both Low and Full Useful Life Mileages
- **As A Result, Our Investment in LEV/ULEV Technology is Discounted, Because the Benefits are Greatly Diminished by Sulfur in Gasoline**
- **There is No Apparent “Safe” Threshold Sulfur Level; Impacts Are Greater at Lower Sulfur Levels**